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Final report

Small research and development activity

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Contents

1 Acknowledgments

We acknowledge pearl farmers at Mtwara, Chole Bay (Mafia Island) and Zanzibar for their assistance with this project. The University of Dar-es-Salaam is also acknowledged for its administrative support of the project.

2 Executive summary

Coastal communities in Tanzania depend primarily on exploitation of coastal and marine resources for their livelihoods (Edward, 2009). Two prior pilot-scale research projects, begun in 2003, assessed the feasibility of developing pearl culture-based livelihoods in poor coastal communities at Mafia Island and Zanzibar. They demonstrated that, after basic training, artisanal fishers could routinely produce marketable cultured half-pearls and that pearl shell handicraft skills were readily adopted by pearl farmers and other community members (Southgate et al., 2006; Jiddawi, 2008). Production of half-pearls and mother-of-pearl (MOP) handicrafts provides broad income generating opportunities for coastal communities in Tanzania (Southgate et al., 2006; Jiddawi, 2008) and half-pearl culture is compatible with marine conservation efforts (Southgate et al., 2006). An associated coastal livelihood opportunity is provided by collection of juvenile pearl oysters or 'spat' that can be retained and grown for subsequent half-pearl production or sold directly to pearl farmers. Spat can be collected by deploying appropriate materials (or 'spat collectors') into the ocean, at an appropriate time, to provide a settlement substrate for pearl oyster larvae that are later removed as spat (Beer and Southgate, 2000; Southgate, 2008). Spat collection is a major source of income for coastal communities in French Polynesia (Southgate et al., 2008; Tisdell and Poirine, 2008) but is at a very early stage of development in Tanzania.

The overall aim of the project was to develop a basic culture protocol to support pearl culture development in Tanzania. This project involved Mr Ismail Saidi, an AusAID supported MSc graduate in Aquaculture (James Cook University, JCU) who returned to Tanzania in 2013 to undertake in-country coordination of this project. Institutional support for Mr. Saidi was provided by the University of Dar-es-Salaam (UDSM) and a UDSM Master's student was engaged in spat collection research at Mtwara and Zanzibar as part of this project. Project research focused on the two most productive community-based pearl farms in Tanzania – a farm in Mtwara producing half-pearls from the black-lip pearl oyster (*Pinctada margartifera*) and a farm in Zanzibar producing mabé pearls from the winged pearl oyster (*Pteria penguin*).

Spat collection infrastructure deployed at both Mtwara and Zanzibar was successful in regular collection of spat of both *Pinctada margaritifera* and *Pteria penguin*; for example, the first collection at Mtwara yielded 73 *P. margaritifera* and 26 *Pt. penguin*. Growth trials were established at both study sites using resulting spat, with growth rates for both species being similar to those reported from other countries and the Pacific. While it was initially proposed to undertake hatchery production trials in the project, neither of the three hatchery facilities inspected were suitable for project research. Instead, emphasis was placed on expansion of spat collection activities and associated extension to maximise the number of spat available to current and prospective pearl farmers.

Spat collection and half-pearl production data generated by the project were used to develop economic models for community-based spat-collection farms and half pearl farms in Tanzania. Outputs include establishment and operational costs, and estimates of potential profitability estimates, for different sizes of spat collection farms and half-pearl farms. The information generated was published in a peer-reviewed journal and is of considerable use to donor and support agencies potentially involved in further pearl industry development work in Tanzania. Extension materials relating to oyster collection, oyster culture, half-pearl production and potential profitability of these activities were developed during the project and translated into Swahili.

3 Introduction

Coastal communities in Tanzania depend primarily on exploitation of coastal and marine resources for their livelihoods (Edward, 2009). Existing livelihood activities include artisanal fishing and mangrove harvesting, agriculture of coconuts and cashews and subsistence farming. However, opportunities for further development of these activities are limited, and this increases exploitation pressures on marine resources, which are often harvested using unsustainable methods such as dynamite fishing and beach seining (Andrews, 1998). To address this underlying dependency on natural marine resources, as well as poverty alleviation, two independent pilot-scale research projects were begun in 2003 to assess the feasibility of developing pearl culture-based livelihoods in poor coastal communities at Mafia Island and Zanzibar. They demonstrated that, after basic training, artisanal fishers could routinely produce marketable cultured half-pearls and that pearl shell handicraft skills were readily adopted by pearl farmers and other community members (Southgate et al., 2006; Jiddawi, 2008). Production of half-pearls and mother-of-pearl (MOP) handicrafts provides broad income generating opportunities for coastal communities in Tanzania (Southgate et al., 2006; Jiddawi, 2008) and half-pearl culture is compatible with marine conservation efforts (Southgate et al., 2006).

As well as half-pearl production, an associated coastal livelihood opportunity is provided by collection of juvenile pearl oysters or ‘spat’ that can be retained and grown for subsequent half-pearl production or sold directly to pearl farmers. Spat can be collected by deploying appropriate materials (or ‘spat collectors’) into the ocean at an appropriate time to provide a settlement substrate for pearl oyster larvae that are later removed as spat (Beer and Southgate, 2000; Southgate, 2008). Spat collection is a major source of income for coastal communities in French Polynesia (Southgate et al., 2008; Tisdell and Poirine, 2008) and has become an important sector in the pearl culture industry (Tisdell and Poirine, 2008). Spat collection is still at a very early stage as a means of income generation in Tanzania, but it has considerable potential should pearl farming become established.

As a result of these significant outputs and clear potential for supporting coastal livelihoods, pearl culture features in the National Fisheries Policy, and “aquaculture development”, “applied strategic research”, “community participation” and integration of “environmental protection and development” are major components of the Tanzanian Government’s Fisheries Sector Policy and Strategic Statement. More broadly, this model has considerable regional potential in east Africa and this aspect has been recognised by the FAO and WWF.

Despite the promising results of pilot activities, key technical and strategic issues need to be addressed to maintain current momentum and for further development of pearl culture in a sustainable manner. A major consideration is oyster supply. Most oysters used for pearl production during pilot activities so far were wild collected adults. Collection of adult oysters is not sustainable, and establishment of a reliable spat collection program is a priority. The potential of hatchery production from existing hatcheries also needs investigating as a supply of oysters for culture. Assessment and adaption of existing culture methods (developed in the Pacific) for Tanzanian conditions is another key requirement for further development.

4 Research Strategy and Partnerships

The main research questions to be addressed by this project were:

- Can methods developed for pearl culture in the Pacific islands be applied successfully in Tanzania and what are appropriate production, husbandry and culture protocols for pearl oysters in Tanzania?
- What factors (temporal and physical) affect pearl oyster recruitment in Tanzania and can a village-based spat collection program support expansion of pearl culture activities in Tanzania?
- Is hatchery production of pearl oyster spat feasible using existing hatchery infrastructure in Tanzania and can hatchery production provide a basis for expansion of pearl culture in Tanzania?

The institutions collaborating in this project were the Department of Marine Resources; Department of Fisheries Development, from within the Ministry of Fisheries, Tanzania; the Institute of Marine Science (IMF); the University of Dar-es-Salaam, Tanzania; The World Wide Fund for Nature (WWF); provincial government and local community groups. The IMF (Zanzibar) and WWF (Mafia) have run independent pearl culture programs over recent years which are now coming to an end. This project fostered a collaborative research approach in Tanzania, coordinated at a national level by the Department of Marine Resources (Aquaculture).

5 Research Objectives

The overall aim of the project was to develop a basic culture protocol to support pearl culture development in Tanzania.

The specific objectives of the project were:

- To generate information on the seasonality of pearl oyster recruitment to spat collectors and optimise methods for spat collection (i.e. soak time, substrate type, depth etc).
- To assess current hatchery facilities (Zanzibar and Mafia Island) for their suitability for pearl oyster culture and determine their capacity to support pearl culture in Tanzania.
- To assess pearl oyster culture methods developed in the Pacific islands for nursery and grow-out culture in Tanzania and modify, where required, to develop a standard protocol for pearl oyster culture in Tanzania.
- To develop extension material relating to spat collection, hatchery, nursery and grow-out culture for pearl culture in Tanzania.

6 Achievements against project activities and outputs/milestones

Objective 1: To generate information on the seasonality of pearl oyster recruitment to spat collectors and optimise methods for spat collection

No.	Activity	Outputs/ milestones	Comments
1.1	Recruit a postgraduate research student from UDSM	A capable student able to undertake a rigorous spat-collection project.	A UDSM Master's student and aquaculture graduate Mr. Musa Ally Hamisi began his research in October 2014. He studied spat collection at the two major farming sites (Mtwara and Zanzibar) that focus on two different culture species (*Pinctada margaritifera* and *Pteria penguin*, respectively). His study included investigation of temporal pattern in recruitment of target species, the effects of factors such as collector depth and collector type/material and growth rates of the spat/juveniles of both target species.
1.2	Establish spat collection infrastructure at four sites	Operational spat collection equipment at each research site.	Spat collection infrastructure was initially deployed at Mtwara in July 2014 and at Zanzibar in August 2014. These consisted of two sub-surface longlines supported by floats and anchors supporting 33 dropper lines (at 1.5 m intervals) each connected with 10 spat collectors spaced at 1-m intervals in the water column. Spat collectors were composed of 1-m^2 of 50% shade cloth held within 6 mm pore size mesh 'onion-bags'. After initial deployment, spat collection infrastructure was entangled in fishing nets and cut by fishers. In Zanzibar, large number of droplines and collectors were lost (presumed stolen). Lost infrastructure was immediate re-deployed. Note that for logistic reasons project research occur at two sites (not four as originally planned). The two sites used are the major pearl farming sites in Tanzania; Mtwara and Zanzibar.
1.3	Monitor recruitment to spat collectors	Temporal data on recruitment pattern of pearl oysters to spat collectors. Information on optimal depths and appropriate materials to use for pearl oyster spat collection in Tanzania.	Because of delays in establishing spat collectors at research sites, recruitment to spat collectors began in Mtwara in May 2015 where 73 *Pinctada margaritifera* spat and 26 *Pteria penguin* spat were harvested. Farmers in Mtwara provided words of thanks to this project from increased supply of oysters to their farm from the first inspection of spat collectors. They could not culture that many oysters in the past due to short supply of wild adult oysters. The proportion of *P. margaritifera* (of total catch) was higher at Mtwara than Zanzibar. Spat yields (both species) were higher in the dry season (Jun-Nov) than wet season (Dec-May).

PC = partner country, A = Australia

Objective 2: To assess pearl culture methods developed in the Pacific islands for nursery and grow-out culture in Tanzania

No.	Activity	Outputs/ milestones	Completion date	Comments
2.1	Recruit a postgraduate research student from UDSM	A capable student able to undertake a rigorous spat-collection project.	N/A	It was initially anticipated that a second UDSM Master's student would be taken on to assess the suitability of Pacific island pearl culture methods in Tanzania. Following input from project stakeholders at the project meeting in April 2014, it was decided that this aspect of Project research would be undertaken by the Project Scientist Ismail Saidi.
2.2	Establish growth trials with recruited spat at four sites	Information on the optimal culture conditions for oyster spat addressing the effects of culture unit, depth and density). Information that will provide a basis for developing a standard protocol (2.4) for use in training and extension manuals and materials (Objective 4).	Sept., 2015	Growth trials were established in Mtwara using spat from the first spat collector harvest in May 2015. Growth rates were measured for the first time (after 4 months) in early September 2015 when a similar growth trial was established at Zanzibar. Note that project research only occurred at two sites (not four as originally specified) for logistic reasons. The two sites are the major pearl farming sites in Tanzania. Some small-scale experiments to assess factors affecting pearl quality (culture duration/depth) were established on the pearl farms at Mtwara and Zanzibar. Depth (to 10 m) did not affect pearl quality at either sites, and a culture period of 10-12 months is recommended.
2.3	Run small training course at each site for community members	Community members that are familiar with the requirements of pearl farming and the methods employed.	August, 2014	The project scientist Mr. Ismail Saidi conducted practical training on construction and deployment of spat collection infrastructure and husbandry to seven members of the pearl farming group at Nyamanzi village, Zanzibar and four members in Mngoji village in Mtwara. This training was also provided to the UDSM student to enable him to carry out his research using standardised methods. The pearl farmers were also trained on appropriate half-pearl seeding methods and oyster husbandry supporting improved pearl quality. This training activity also included provision of commercially available pearl nuclei (3,000 nuclei) to pearl farmers in Mtwara and Zanzibar supporting improved pearl quality and pearl value. Pearl farmers previously used inappropriate alternatives.

2.4	Develop standard protocol for pearl oyster culture in Tanzania based on project results	A protocol that can be used as a basis revision of manuals and extension materials.	March, 2016	Milestone completed and extension materials were developed for pearl farm set-up, spat collector set-up, general culture methods and pearl production. These extension materials were translated into Swahili and used in project extension activities.

PC = partner country, A = Australia

Objective 3: To assess current hatchery facilities (Zanzibar and Mafia Island) for pearl oyster production and determine their capacity to support pearl culture in Tanzania

No.	Activity	Outputs/ milestones	Completion date	Comments
3.1	Undertake hatchery runs at each facility to include training	Successful hatchery run that produces juveniles. Personnel from partner organisations that have been trained in hatchery techniques and pearl oyster husbandry and larval culture.	N/A	Problems were encountered with both of the hatchery facilities initially identified for use in this project which were considered unsuitable for project research. The hatchery facility at the UDSM Kunduchi campus was considered as an alternative but the cost of repair and replacement of key equipment required to bring the hatchery to operational standard was significant and beyond the scope of this small project. Because spat collection efforts proved successful and require simpler technology more appropriate to rural communities, hatchery production was not pursued further in this project. Instead, emphasis was placed on expansion of spat collection activities and associated extension to maximise the number of spat available to current and prospective pearl farmers.
3.2	Assess use of commercially available micro-algae in hatchery production	Successful large-scale hatchery production of *P. penguin* using only algae pastes as a food source.	N/A	Commercially available algae pastes were to be used as the sole larval food source during hatchery production. However, the planned hatchery activity did not take place.

Objective 4: To develop extension materials and international linkages

No.	Activity	Outputs/ milestones	Completion date	Comments
4.1	Use outputs from Objectives 1,2 and 3 to revise existing extension materials	Up-to-date manuals covering spat collection, oyster husbandry and pearl production and harvest.	Mar., 2015	Manuals developed for extension activities undertaken by the Project Leader in prior research in Tanzania provide the basis for developing contemporary, simplified manuals that incorporate project findings. Extension materials were developed to cover site selection, spat collector and farm set-up, half-pearl seeding, oyster husbandry and economic aspects of spat collection and pearl production. They were translated into Swahili for use in pearl culture extension activities.

4.2	Translate extension materials and distribute to stakeholders	Pearl culture manuals in Swahili that are more easily interpreted by existing and prospective pearl farmers and extension officers.	May, 2015	Milestone completed – see comment above.
4.3	Conduct international workshop at end of project	Dissemination of project findings to an international audience. Investigate further opportunities for support and funding for development of the pearl culture industry in Tanzania and east African.	N/A	Unfortunately, funds were not available at the end of the project to support the planned workshop. This resulted from greater than expected expenditure for project travel, meetings, student support and project support by UDSM.

7 Impacts

7.1 Scientific impacts

This project had scientific impacts in the following areas:

- **Pearl oyster culture**: new information on spat collection and field-based culture of juvenile and adult *Pteria penguin* and *Pinctada margaritifera* improved oyster availability, helped develop improved culture methods and provided growth rate and other biological information for pearl oyster culture in Africa for the first time.
- **Pearl culture economics**: Mr Ismail Saidi and the Project Leader worked with the Senior Agricultural Economist of Queensland DAF (Bill Johnston) to model economic aspects of pearl farming practices in Tanzania. The model provides valuable new information regarding establishment and running costs of community-based pearl farms and their potential profitability, relative to size.
- **Postgraduate students**: the project involved a Master's research student from UDSM. The activities of postgraduate students broaden project outputs, increase the project's contributions to current scientific knowledge and raise the profiles of both ACIAR's Fisheries Program and mariculture research in the region. Additionally, in his role within the project, Ismail Saidi, was able to apply scientific knowledge gained while studying in Australia to address industry relevant issues in his home country. Both build regional capacity in pearl culture.
- **Publications**: this project developed new methods and techniques and applied existing scientific and culture techniques in novel ways. It also involves a postgraduate research student. Project research resulted in a international journal publication. A number of manuals on pearl culture will be produced supporting extension activities.

7.2 Capacity impact

The capacity impacts from this Project include:

- Pearl farmers (and the industry as a whole) built production capacity through improved access to, and greater availability of, pearl oysters as a result of spat collection. Standard spat collection methods were developed and appropriate extension will provide farmers (and prospective farmers) with the means to maximize production capacity of their farms.
- Development of economic models describing establishment and operation costs for spat collection and half-pearl farms of varying sizes has brought a number of capacity impacts including: (1) improved capacity of donor and research organisations to assist in this field; (2) improved capacity of farmers, prospective farmers and extension and support agencies to asses potential benefits and relative profitability of various levels of production or expansion.
- Tanzanian expertise in pearl culture was significantly boosted during this project: (1) Ismail Saidi completed his MSc (Aquaculture) at James Cook University (JCU); this project allowed him to further develop his pearl culture expertise in his home country – his expectation is to lead future pearl culture developments in Tanzania; (2) academic, research and technical staff at UDSM, as well as government staff, will build capacity in the field of pearl culture through their direct involvement with Project activities; (3) pearl farmers will benefit directly through improved culture methods that will improve pearl oyster growth rates, health and pearl quality.

- This project involves a Tanzanian post-graduate research student who undertook both laboratory and field-based research activities using contemporary pearl culture methods. He was involved in the day-to-day running and with aspects of project planning, and liaison at farm and community levels. These experiences are important components in building scientific capacity within the country.
- It is expected that the outputs of this project could provide a basis for significant expansion of community-based pearl farming in Tanzania.

7.3 Community impacts

The community impacts of pearl farming and associated activities such as handicraft production are broad yet poorly documented but positive community benefits resulting from pearl culture have already been documented in Tanzania (Southgate et al., 2006; Jiddawi, 2008); they include increased livelihoods opportunities, enterprise development, empowerment of women, income generation and reduction of 'urban drift'.

7.3.1 Economic impacts

The economic impacts of pearl culture are potentially broad. They encompass livelihood opportunities based on pearl production as well as associated activities such as pearl and pearl shell handicraft production. Economic opportunities from pearl culture are enhanced in Tanzania because of its significant tourism sector composed of a broad range of visitors (from backpackers to high-end tourists) potentially supporting production of both handicraft and high-quality pearl products.

The economic impacts of pearl production in Tanzania are evident as outcomes from prior pilot scale projects. At Mafia Island, for example, pearl farming supported an increase in the household incomes of ex-fishermen from below the national average to six-times above the national average. Similar impacts have been seen in Mtwara and Zanzibar where the economic impacts also include income generation from new businesses developed from pearl earnings (such as boat purchase and hire), opportunistic activities like pearl farm visits for tourists, and from associated activities like pearl and pearl shell jewellery and handicraft production and sales (Jiddawi, 2008). A partner pearl farmer in Mtwara, for example, invested some income generated from pearl culture into construction of concrete block house which includes a handcraft workshop and sales room for pearls and handicraft items.

While the economic impacts of this project are limited so far, given the duration of this project relative to the pearl growth and pearl production cycle (~ 3 years), it is anticipated that expansion of community-based pearl farming in Tanzania would bring similar benefits to those highlighted above to many more communities in coastal Tanzania. Economic models generated for spat collection farms and half-pearl farms have indicated minimum viable sizes for both enterprises and predict potential profitability for varying degrees of engagement with both activities. It is very clear that both activities can provide substantial income for farmers and communities and can be profitable enterprises (Saidi et al., 2017).

7.3.2 Social impacts

This project aimed to provide direct benefits to communities in rural and economically depressed areas of Tanzania through establishment or expansion of pearl farming activities resulting in employment opportunities, income generation, and associated health, educational and social benefits. Research outcomes also included improved livelihood opportunities through associated activities such as handicraft production. The latter is likely to be of particular benefit to women and younger people. In Pacific island countries, development of community-based livelihood opportunities has been shown to reduce the migration of people (especially youth) to larger towns and cities, bringing social

benefits to the communities involved and to the country as a whole (e.g. Arnaud-Hoand et al., 2003; Andrefouet et al., 2012).

7.3.3 Environmental impacts

Pearl culture is an environmentally benign form of aquaculture. It utilises suspended culture methods which minimise benthic impacts, and it is usually conducted away from coral reefs to minimise predation of farmed oysters. Pearl farming often has positive environmental impacts including:

- pearl oyster culture equipment may act as fish aggregating devices and can result in increased local availability of food fish (Cartier and Carpenter, 2014);
- routine spat collection of oysters provides oyster stock for pearl farmers thereby reducing collecting pressure on local wild oysters; and
- provision of alternative livelihood opportunities (such as pearl farming and associated activities) in coastal eastern Africa reduces fishing effort that includes destructive fishing practices such as dynamite fishing.

8 Communication and Dissemination Activities

- Formal meetings with all stakeholders and project partners including representatives from various sections of the Tanzania main land and Zanzibar governments (relevant Ministries, Marine Parks, etc.), the University of Dar-es-Salaam (UDSM) (Faculty and IMS, Zanzibar) and WWF to inform of project objectives, discuss research priorities, project roles and responsibilities and to inform of project progress.
- Visits to pearl farming communities at Mtwara, Mikindani and Zanzibar and to community pearl handicraft groups (Mtwara and Zanzibar) to outline project objectives, seek feedback about pearl farming activities and bottlenecks to development, to provide extension/training activities and assess progress.
- Meetings with UDSM Faculty of Fisheries Science and Aquaculture senior staff to discuss formal project partnership supporting project activities and update progress.
- Formal meetings with all stakeholders and project partners (see above) to discuss project research plan, introduce the new MSc student, develop a timeline for field-based research and to review progress and research issues.
- Meeting with Aquaculture stakeholders from the Western Indian Ocean regional countries to discuss opportunities and challenges facing development of aquaculture industry in this region. The Project Scientist Mr. Saidi made presentation on economic modelling of community based half-pearl culture conducted with support of this project.
- Journal publication:

  Saidi, I., Johnston, B., Southgate, P.C. 2017. Potential profitability of pearl culture in coastal communities in Tanzania. *Aquaculture Reports* 5, 10-17.

9 Training activities

A number of training activities took place and the project team provided technical advice on many occasions to pearls farmers and pearl handicraft artisans and women's/community groups. Training activities include:

- Practical training to pearl farmers and UDSM MSc's student on construction of spat collection infrastructure and deployment.
- Practical training to pearl farmers on appropriate half pearl seeding methods (Appendix 1) for oysters and oyster husbandry to improve health, growth rate and pearl quality. This activity went hand in hand with delivery of 3,000 commercial nuclei to pearl farmers. These interventions resulted in improved pearl yield and quality.

Current and prospective pearl farmers and staff from partner institutions receive training on bamboo raft construction for pearl oyster spat collection and pearl culture.

10 Variations to Project activities and Personnel

Field-based research in this project began later than anticipated to allow completion of Ismail Saidi's study in Australia and his return home to oversee project activities in Tanzania. Delays were also experienced relating to student engagement with the project and with project infrastructure being destroyed. Because of such delays, a project extension was granted to 31 March 2016.

It was initially proposed to undertake hatchery work at both the IMS facility in Zanzibar and the WWF hatchery at Mafia Island. However, both facilities were unsuitable for project research; developments in the Zanzibar harbour area negatively affected water quality at IMS and the WWF facility was in a poor state of repair. Instead, the hatchery facility at the University of Dar-es-Salaam's (UDSM) Kunduchi campus was investigated but the cost of bringing this facility to usable condition would be prohibitive and beyond the scope of the project. Because spat collection efforts proved successful and require simpler technology more appropriate to rural communities, hatchery production was not pursued in this project. Instead, emphasis was placed on expansion of spat collection activities and associated extension to maximise the number of spat available to current and prospective pearl farmers.

The number of research sites was reduced to the two main pearl farms at Zanzibar and Mtwara. This decision aligned project research with the two most productive farms in Tanzania – producing pearls from the black-lip pearl oyster (*Pincatda margartifera*) and the winged pearl oyster (*Pteria penguin*).

Mr. Ismail Saidi was employed as Project Scientist through UDSM. He coordinated and managed project research in Tanzania following consultation with, and under the direction of, the Project Leader. He worked under the in-country supervision of Dr. Rashid Tamatamah of the Department of Fisheries Science and Aquaculture at UDSM who works closely with the Australian Project Leader (Southgate).

A University of Dar-es-Salaam (UDSM) Master's student Mr. Musa Ally Hamisi began research into spat collection at Mtwara and Zanzibar in October 2014. His research was co-supervised by Tamatamah and Southgate and his day-to-day activities were supervised by Ismail Saidi.

The Project Leader (Southgate) relocated from James Cook University to the University of the Sunshine Coast (USC) in January 2015, and USC became the commissioned organisation for this project.

11 Problems

This project made a slow start. From an operational perspective it required full-time in-country oversight and a reliable project partner to undertake in-country administration and financial responsibilities. These issues were addressed by delaying much of the proposed research until Ismail Saidi returned to Tanzania, following training in Australia and through subsequent development of a comprehensive MOU with the University of Dar-es-Salaam as a basis for progress.

The project also encountered non-intentional destruction of spat collection infrastructure by fishers at both research sites (Mtwara and Zanzibar) due to entanglement of fishing nets in spat collection structures during fishing activities. This event called for revision of the methodology employed in setting spat collection infrastructure and re-deployment; however, delays to project activities and outputs resulted.

Some research opportunities arose that broadened the initial scope of the project. Small scale experiments with wild collected oysters were established on the pearl farms at Mtwara and Zanzibar to assess culture methods and factors affecting pearl quality. Informal training of two farmers in methods for half-pearl production was included in this work. While the project objectives do not include pearl production and pearl quality these aspects are an important part of industry development, and the results were included in economic assessment of mabé pearl production in Tanzania, and contributed to the project's publication output (see section 13.2).

12 Conclusions and recommendations

12.1 Conclusions

The results of this project demonstrate that pearl oyster spat collection and mabé pearl production can be undertaken successfully and profitably in Tanzania using methods established for pearl farming in the Pacific. Economic modelling confirmed the economic viability of these activities which offer alternative livelihoods options for coastal communities. Given the dependence of such communities on the exploitation of coastal and marine resources for their livelihoods, and the limited opportunities for further development of these activities, the pearl sector may offer more sustainable and environmentally sensitive income generating opportunities. As well as direct benefits from spat or mabé pearl production, downstream activities, such as handicraft production using pearl shell, pearl farm tours and other tourist activities, broaden further the economic opportunities that pearl culture may support.

12.2 Recommendations

Further development of the pearl sector in Tanzania is recommended on the basis of the opportunities described above (section 12.1). Such opportunities are not limited to Tanzania but would have regional potential.

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13.2 List of publications produced by project

Saidi, I., Johnston, B., Southgate, P.C. 2017. Potential profitability of pearl culture in coastal communities in Tanzania. *Aquaculture Reports* 5, 10-17.

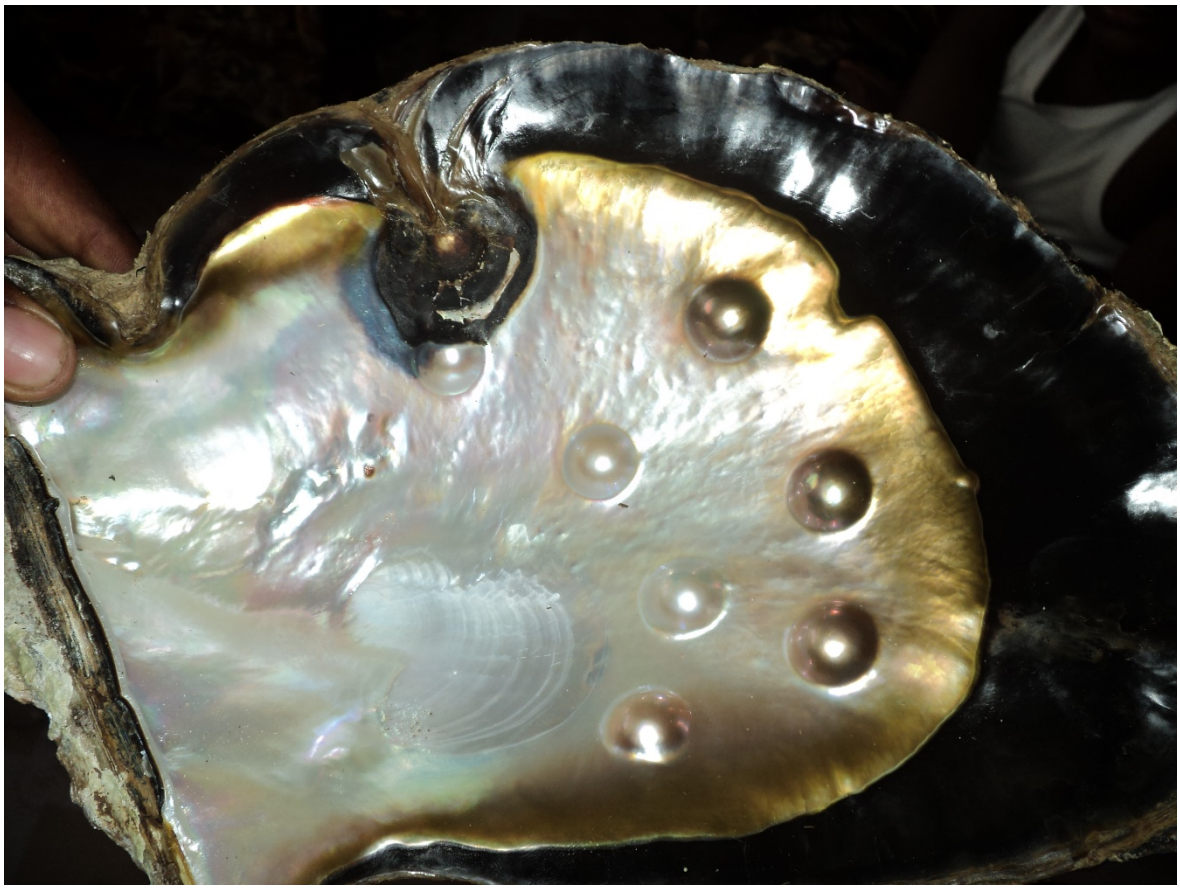
14 Appendixes

14.1 Appendix 1: Photographs

‘Seeding’ for mabé pearl production

Training in mabé pearl seeding

Pearl farmer inspects his stock at Mtwara.



Tanzanian mabé pearls.